INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
IFPRI

REGIONAL PROGRAM WORKING PAPER 42 JANAURY 2023

Smallholder Farmers' Participation in Profitable Value Chains and Contract Farming: Evidence from Irrigated Agriculture in Egypt

Martin Paul Jr Tabe-Ojong and Kibrom A. Abay

ABSTRACT

The participation of smallholder farmers in high-value and profitable value chains as well as contract farming remains low in Africa. This paper aims to identify observable and unobservable constraints that explain joint participation in profitable value chains and contract farming. We use a multivariate probit model to estimate potential complementarities between the cultivation of these various value chains (vegetables, fruits, spices, herbs, and cereals), and participation in contract farming. We identify several important observable factors that reinforce and hence limit smallholders' participation in both low and high-value chains as well as contract farming. For example, we find suggestive evidence that smallholders in Egypt face a trade-off between ensuring food security to their households and maximizing profit, and land plays a major factor in moderating this trade-off. We find that farmers with limited land resources are more likely to devote a larger share of their land to low-value crops such as cereals while this pattern weakens with increasing land size and slightly reverses for high-value crops such as spices and herbs. This suggests until some level of land resources, food security goals may dominate profit motives while this reverses after ensuring that food security goals are achieved. Younger and wealthier farmers are more likely to participate in the cultivation of high-value crops such as spices and herbs as well as contract farming. We also document strong complementarities between participation in high-value value chains and contract farming. Particularly, farmers who cultivate high-value crops are more likely to be engaged in contract farming. Intuitively, this implies that addressing smallholders' binding constraints, including risk and access to land, can encourage participation in profitable value chains and contract farming. Our findings offer suggestive evidence that may serve in targeting smallholders to join profitable value chains in Egypt and other comparable contexts.

Keywords: high-value value chains; low-value crops; contract farming; complementarities; trade-offs; Egypt.

JEL codes : C31, C35, D8, Q12, Q13, Q14.

1. INTRODUCTION

Agri-food value chains continue to trigger significant interest in both research and public policy discourse (Barrett 2008; Bellemare et al. 2022). This is not surprising given the importance and resilience of the agri-food value chains in domestic and global food systems.[1] The transition of smallholder farmers from production geared at meeting household food demands to production geared for income and profitability motives is of key importance for developing countries (Barrett 2008 ; Bellemare 2012 ; Otsuka et al. 2016 ; Arouna et al. 2021 ; Tabe-Ojong et al. 2021 ; Biggeri et al. 2022). Typically, agricultural households in many African countries only participate in agricultural production and marketing to satisfy their household food demands. Theoretically, households in the upstream segments may decide to produce low-value crops for consumption purposes or high-value crops for profitability motives (Ashraf et al. 2009).[2] In leveraging these production and consumption decisions, smallholder farmers in Africa face a myriad of challenges including but not limited to low productivity, market failures, credit constraints, and high transaction costs which deter them from participating in markets (Swinnen and Kuijpers 2020; Bellemare et al. 2022).

High transaction costs in many staple markets may alter the optimal choice of most households to self-sufficiency (Key et al. 2000; Barrett 2008; Renkow et al. 2004; Tabe-Ojong et al. 2021). If these transaction costs are high and oriented towards the labor market, such as searching for workers or monitoring worker efforts, they could cause households to rely more on family labor and less on hired labor. Poor households in Africa usually lack access to credit as their assets and collateral value is low. In the face of such liquidity and credit constraints, households may be risk-averse and less likely to optimally invest in high-return investments.

The scale and environment of production that smallholders operate entails significant risk and multiple constraints that reinforce each other. For example, in the context of evolving land scarcity in Africa, participation in market-oriented production systems and contract farming may entail some risk and trade-off with food security targets. These reinforcing constraints are likely to limit smallholders' participation in high-value production systems and modern farming systems. Relatedly, farmers are also exposed to recurring price risks and uncertainties in markets that may affect their investments in risky but profitable value chains (Chavas 2019; Boyd and Bellemare 2020).

Given these challenges and constraints, many governments in Africa have been pursuing several initiatives to facilitate the transition of smallholder farmers to market-oriented agriculture. Supporting smallholder farmers to participate in high-value and profitable value chains has been one of these initiatives. This has largely taken the form of various programs geared at increasing productivity and improving rural and market infrastructure to reduce transaction costs. Relatedly, contract farming has emerged as a viable institutional tool to boost the realization of these goals by addressing different aspects of market failures (Barrett et al. 2012; Bellemare and Bloem 2018; Bellemare et al. 2022). Contract farming stands

1 Agriculture in general and agri-food value chains, in particular, proved to be resilient to the COVID-19 pandemic as well as related shocks (e.g., Arndt et al. 2020; Zeufack et al.; Vos et al.2022)

2 This refers to the production of crops while the downstream segment refers to the marketing of crops

the promise of establishing and solidifying linkages between farmers and other actors in the value chain, enabling them to enjoy market opportunities (Biggeri et al. 2022). Contract farming may be even more appealing for high-value crops since they require substantial amounts of farm inputs such as fertilizers and pesticides which may often be provided through contracts. Contract farming has been shown to be associated with significant productivity and welfare effects (Miyata et al. 2009; Maertens and Swinnen 2009; Bellemare 2012; Wang et al. 2014a; Wang et al. 2014b; Maertens and Vande Velde 2017; Ton et al. 2018; Meemken and Bellemare 2020; Arouna et al. 2021).[3] However, participation of smallholder farmers in these emerging value chains and contract farming in Africa remains low (Minot and Sawyer 2016). Explaining this disappointing trend requires further research. Empirically, this requires characterizing farmers' participation in various value chains and contract farming.

In this study, we identify observable and unobservable factors that may constrain the participation of farmers in profitable value chains and contract farming, which can reinforce each other in most cases. We also examine the complementarities and trade-offs in participation in profitable value chains and contract farming. We examine participation in high-value horticultural chains such as vegetables, fruits, spices, and herbs as well as less profitable value chains such as wheat and maize, which are cultivated by households for varying purposes. We then assess whether participation in these various value chains encourages or discourages subscription to contract farming. Previous studies have examined participation in profitable value chains and contract farming in a univariate setting while our approach acknowledges the potential bidirectional relationship between contract farming and crop choice. Some observable and unobservable factors that affect or constrain households' crop choice may also affect access to or propensity to participate in contract farming. Our multivariate probit model explicitly accounts for these observable and unobservable factors.

In establishing these relationships, we also identify some of the correlates of the choice of these value chains and contract farming. We use detailed plot-level data from seven governorates in Upper Egypt and estimate a multivariate probit model which jointly examines participation in value chains and contract farming while allowing potential interdependencies in these decisions. Egypt is an interesting case to examine these relationships given its reliance on irrigated agriculture and encouraging market-oriented production systems, which remains a top priority of the government. Most of the empirical evidence on value chain participation and contract farming is based on rainfed agriculture (Otsuka et al. 2016; Bellemare and Bloem 2018; Bellemare et al. 2022). Little empirical evidence on contract farming exists from irrigated agriculture especially from the Middle East and North Africa (MENA) region, to which Egypt belongs (Bellemare and Bloem 2018). New evidence is warranted given that the major production and farming systems are different in both cases. Moreover, smallholder farmers in this region compete with large commercial farmers in the production of high value crops, both in local and internal markets (Abay et al. 2022a).

We find that several observable and unobservable factors reinforce and hence limit smallholders' participation in both high-value crops and contract farming. For example, we find nonlinear relationship between land resources and participation in less profitable value chains such as cereals. This is likely to be driven by the important trade-offs between food security and profit motives of smallholder households. Younger and wealthier farmers are more likely to participate in cultivation of high-value value chains such as spices and herbs. We also find important trade-offs and complementarities between profitable value chains and contract farming: those smallholders cultivating high-value and profitable crops are more likely

3 They could also lead to negative or no effects (Narayanan 2014; Minot and Sawyer 2016; Otsuka et al. 2016; Ragasa et al. 2018.

to participate in contract farming. We also identify various household and farm characteristics that explain participation in different value chains and contract farming.

Our analysis offers three main contributions to different strands in the empirical literature on smallholder farmers' participation in agri-food value chains. First, we consider the interrelationship between participation in various value chains and contract farming. Previous studies have mostly analyzed these outcomes independently and ours is the first study to establish this seemingly inherent relationship between different value chains and contract farming. As alluded above, there exists a burgeoning literature on value chain participation and contract farming (Wang et al. 2014a; Otsuka et al. 2016; Bellemare and Bloem 2018; Bellemare et al. 2022), but they do not model the complementarities and trade-offs in these chains and contract farming. Second and related to the first, we use rich plot-level data through which we identify various factors and constraints that explain smallholders' participation in various value chains and contract farming. Third, we provide evidence in the context of irrigated agriculture which remains an underexplored part of the value chain literature. We consider the case of irrigated agriculture in Egypt where farmers cultivate both horticultural crops and cereals but are unable to meet their household consumption demands of major cereals such as wheat. Beyond these empirical contributions, our analysis is well-placed to inform policies aiming to boost smallholders' participation in profitable value chains. As Egypt is the largest wheat importer in the world, most of which come from Russia and Ukraine, these findings are even more relevant given the Russia-Ukraine crises which poses serious threats to wheat imports, threatening food security (Abay et al. 2022b). Indeed, this has reignited the debate on food "self-sufficiency" and many argue that boosting domestic production of low-value cereals could have significant import substitution advantages, although the trade-offs we find in our study are not widely acknowledged.

2. SMALLHOLDER PARTICIPATION IN AGRI-FOOD VALUE CHAINS, CONTRACT FARMING AND RURAL DEVELOPMENT

The transition of smallholder farmers from subsistence farming to commercial farming through their participation in value chains and contract farming continues to attract significant policy and research interests. There exists a large body of empirical literature on the productivity (Key and McBride 2008; Minten et al. 2007; Mishra et al. 2016; Ragasa et al. 2018) and welfare impacts of contract farming (Bellemare 2012; Meemken and Bellemare 2020; Minten et al. 2009; Narayanan 2014). A growing number of reviews have synthesized some of the conceptual and empirical studies on contract farming and their implications (Minot and Sawyer 2016; Bellemare and Bloem 2018; Bellemare et al. 2022). Given this, we prefer not to repeat their reviews here, but guide interested readers to these reviews. Five insights that come out clear from these reviews are: (1) The benefits of participating in high-value value chains and contract farming is largely untapped as participation remains very low (Minot and Sawyer 2016); (2) Despite low participation, contract farming is welfare increasing although some social concerns such as inequality and long working hours remain (Bellemare and Bloem 2018; Bellemare et al. 2022); (3) There exists different welfare implications across high and low-value value chains (Narayanan 2014; Minot and Sawyer 2016; Otsuka et al. 2016; Ragasa et al. 2018); (4) There exists little work that examines the constraints of value chain participation and contract farming (Bellemare et al., 2022), and (5) Significant heterogeneity and context specific studies, suggestive of the need for further studies to generate nuanced and stylized patterns across various contexts (Bellemare and Bloem 2018). We discuss these points in the following paragraphs.

As highlighted, the empirical literature on contract farming is mostly replete with high-value chains such as horticultural and cash crops (Ragasa et al. 2018). Contracting also exists for low-value chains and has been described as inclusive but so far received little attention (Miyata et al. 2009; Swinnen and Kuijpers 2020).4 This may be due to the fact that contract farming may be more attractive and profitable for some value chains than others (Swinnen et al. 2010). Evidence on contracting in staple food value chains is on the increase (Simmons et al. 2005; Maertens and Vande Velde 2017; Ragasa et al. 2018) but little work explores the interrelationships between participation in low and high-value chains and contract farming. Bellemare (2012) and Bellemare and Novak (2017) are probably the only studies that examine the impacts of contract participation over a range of different low and high value crops but they did not jointly model these seeming interrelations.

Moreover, the various barriers households face in participating in value chains and contract farming has been subject to a far less empirical investigation (Ba et al. 2019; Ochieng et al. 2017; Abebe et al. 2013; Holly Wang et al. 2011). Participation in contract farming is driven by a range of socio-economic factors like membership in producer organizations (Ba et al., 2019; Otsuka et al., 2016; Swinnen & Kuijpers 2020), educational level and gender of the household head (Otsuka et al., 2016), with women being less likely to participate (Bellemare 2012; Holly Wang et al. 2011; Meemken and Bellemare 2020). Labor endowment and household size is also an important factor driving participation in contract farming (Ba et al. 2019). Contract farming is also thought to be non-scale neutral (Abebe et al. 2013; Holly Wang et al. 2011; Meemken & Bellemare 2020) wherein most agribusiness and processing firms usually prefer contracting with a few large farmers rather than many small farmers to reduce their transaction costs (Swinnen and Kuijpers 2020). In such cases, land size may be a binding constraint to value chain participation especially in land scarce countries. Given that smallholder farmers consider food security targets and profit motives, the relationships between land resources and participation in high-value value chains or contract farming is likely to be nonlinear. For example, up to a certain level of production, food security targets may dominate profit motives while this can reverse once households ensure household food security goals. This non-linear relationship may further interact with household characteristics that define access to land resources.

3. DATA AND CONTEXT

3.1 Context

Agricultural production in Egypt like in other parts of the MENA region typically relies on irrigation due to extended dry seasons and lack of rainfall. Land resources are scarce and dwindling due to growing population. Farm size continue to decrease, and even more is expected due to inheritance laws, market imperfections and urban expansion (Aboulnaga et al. 2017). Only about 4 percent of the Egypt's land is under agricultural production (FAO 2016). Despite scarce land resources, area under irrigated agriculture has been increasing due to reclamation of new lands (Fuglie et al. 2021). However, growing competition for water resources and associated policy priorities may have different implications on the participation of smallholders in various value chains. Of course, value chains under irrigated agriculture may be considerably different under rainfed agriculture given the substantially different farming environments and

4 This is probably due to the fact that most low-value crops are usually non-differentiated, non-perishable, and usually meant for home consumption. Also, transaction costs associated with accessing output markets are generally low and there are little or no opportunities for value addition and quality upgrading (cf Ragasa et al. 2018).

context. One key difference here is the fact that these farmers tend to compete with both medium and large-scale farmers who in most instances are engaged in high-value value chains. This could lead to significant marginalization and inequity. Beyond participating in high-value chains, farmers are also engaged in the cultivation of low-value crops such as wheat, barley, maize, and other crops that are more inclusive and relevant for food security.

Beyond the usual economic incentives, farmers in Egypt face additional policy induced incentives in their decisions to participate in various value chains. For example, the government of Egypt encourages production of wheat to satisfy food security goals using alternative instruments (e.g., Kassim et al. 2018; Kurdi et al. 2020). Nitrogen fertilizer subsidies in Egypt are geared towards promoting wheat cultivation because wheat requires relatively more nitrogen than phosphate fertilizers (Kassam and Dhehibi 2016). Thus, wheat farmers have better access to subsidized fertilizer (Kurdi et al., 2020). Furthermore, to ensure sufficient wheat supply, the government of Egypt procures wheat from local farmers at government-sponsored procurement price, which is usually above local market price. Although we lack formal evaluations of the implications of these policies, we anticipate that they can affect smallholders' participation and preferences in various value chains.

3.2 Farm household survey

The data for this analysis comes from a survey meant to evaluate a project under the Feed the Future Egypt, Food Security and Agribusiness Support (FAS) project, which sought to boost on-farm production, participation in horticultural value chains, agribusiness activities, and contract farming among smallholders in Upper Egypt. A farm household survey was conducted between April and May 2018 in seven governorates in Upper Egypt (Aswan, Assiut, Beni Suef, Luxor, Menya, Qena, and Sohag). The data collection was part of a baseline survey for an initially planned impact evaluation study of the FAS project. In this regard, two groups of farmers were selected. One group consists of farmers producing various horticultural and cereal crops on at least one of the plots with a total farm size of fewer than 10 feddan.[5] FAS associations were operating in six Upper Egypt governorates (Assiut, Beni Suef, Luxor, Menya, Qena, and Sohag). From these governorates, farmer lists were constructed, and farmers were selected using a stratified sampling approach. To select farmers for the second group, a random walk strategy[6] was used in the same FAS association villages. This makes both groups of households reasonably comparable in several observable characteristics, including scale of production. Although these data are not nationally representative, they are well-suited for evaluating smallholders' participation in various agri-food value chains. The overall features of these data are also comparable with nationally representative data of smallholders in Egypt, particularly in terms of land availability and farming systems in upper Egypt, where most smallholder farmers in Egypt are located (Kurdi et al., 2020).

A group of well-trained enumerators then interviewed households using survey-based tablets. The survey collected information both at the household and plot levels. At the household level, information was garnered on household socio-economic characteristics like education, age, labor, farm size, livestock ownership, and asset ownership and income. At the plot level, information was captured on plot size and the crops cultivated on the plots. For this purpose, the survey collected information for both the winter and

5 1 feddan = 0.42 hectare.

6 This involved identification of a starting point (in most cases the FAS farm household) and the random selection of a household based on a predefined walking route.

summer seasons. The sample covers about 2237 households. A total of 5710 plots were cultivated by farmers across both seasons. On these plots, farmers were cultivating one or more different crops (intercropping). Some of the crops cultivated by farmers include wheat, maize, green beans, onions, tomatoes, sweet potatoes, celery, fennel, basil, marjoram, thyme, anise, parsley, cilantro, dill, cumin, pepper, mint, chamomile, okra, molokhia, lettuce, carrot, beet, cauliflower, eggplant, cucumber, zucchini, fenugreek, corianda, mugworts, caraway, aromatic and medicinal herbs, squash, pineapples, olives, melons, mangoes, tablegrapes, bananas, figs, guavas, tangerines, and, table grapes. We merged these crops into different broad categories of value chains: fruits, vegetables, spices, herbs, and cereals based on their agronomic definition.

Table 1 shows the summary statistics of the various value chains and some explanatory variables. The cultivation of vegetables seems to be the most popular value chain as about 70 percent of farmers are cultivating at least one type of vegetable. Spices and herbs are cultivated in about 12 and 14 percent of plots, respectively. Maize and wheat are two important cereals which are cultivated in about 27 and 34 percent of plots. About 1 percent of sampled farmers are cultivating fruits. The participation of farmers in contract farming is low (6 percent). This participation rates are in line with Minot and Sawyer (2016) who highlighted that only about 1-5 percent of smallholder farmers are involved in contract farming in developing countries. More than half of the plots are intercropped.

3.3 Descriptive statistics and insights

Table 1: Summary statistics

	Mean	Standard deviation
Outcome variables		
Vegetable cultivation (1/0)	0.69	0.46
Fruits cultivation (1/0)	0.01	0.12
Spice cultivation (1/0)	0.12	0.33
Herbs cultivation (1/0)	0.14	0.35
Wheat cultivation (1/0)	0.27	0.44
Maize cultivation (1/0)	0.34	0.47
Contract farming (1/0)	0.06	0.24
Household and plot-level characteristics		
Age of head (years)	47.39	11.47
Head is male (1/0)	0.99	0.12
Non-agricultural occupation (1/0)	0.29	0.45
Incomplete primary education (1/0)	0.19	0.39
Primary education (1/0)	0.08	0.28
Incomplete secondary education (1/0)	0.13	0.34
Secondary education (1/0)	0.39	0.49
Higher education (1/0)	0.18	0.38
Hired labor (1/0)	0.49	0.50
Household size (number)	5.14	1.82
Intercropping (1/0)	0.55	0.50
Plot size (feddan)	1.55	1.69
Farm size (feddan)	2.53	2.55
Tropical livestock units	2.04	1.57
Wealth index	-0.18	1.01
Productive asset index	-0.09	0.79
Number of observations	5710	5710

Notes: Wealth and productive asset index are both created using Principal Component Analysis.

On average, household heads are middle aged farmers of about 47 years, and they are predominantly males. About 71% of them participate in agricultural activities as their primary source of employment while 21% rely on non-agricultural activities for their livelihoods. There exists some level of heterogeneity in education attainment. 40 percent of farmers have attained secondary education and average households consist of about 5 members. Average plot size in our sample amounts 1.5 feddans while average farm size is about 2.5 feddans.[7]

4. EMPIRICAL STRATEGY

We are interested in identifying observable and potential unobservable factors and constraints that limit smallholders' participation in profitable value chains and contract farming. We also aim to quantify the complementarities and trade-offs between participation in various value chains and contract farming. As

7 A feddan is a unit of area commonly used in Egypt equivalent to 0.42 hectares or 1.03 acres.

the cultivation of these value chains and activities are not independent and some of the crops are cultivated on the same plot, we employ a multivariate probit (MVP) model to accommodate these interdependencies (Cappellari and Jenkins 2003). The advantage of this model lies in its ability to identify various factors that explain or limit participation in specific value chains and contract farming while also allowing additional common unobservable drivers that generate complementarities and trade-offs in these choices. In doing so, it allows for flexible correlations in the error terms associated with these various choices and decisions. We estimate complementarity and substitutability across various value chains and contract farming at plot as well as household level. While the plot-level complementarities may be driven by biophysical factors that affect intercropping patterns, the household-level patterns are likely to be driven by economic motives and related diversification and specialization motives. To reduce model complexity and facilitate convergence in estimations, we aggregated some of the value chains. We merged fruits and vegetables as well as spices and herbs to represent different categories of high value and profitable value chains. We also combined wheat and maize and jointly refer to them as cereals which represent less profitable value chains. Our MVP model thus consists of four binary type equations associated with the following value chains: fruits and vegetables, spices and herbs, cereals, and contract farming. The latent decisions and choices of farmers can be represented as follows:

$$Y^*_{ikn} = \boldsymbol{X}'_{ikn}\boldsymbol{\delta}_n + \varepsilon_{ikn} \qquad \text{n = 1, 2, 3, 4} \qquad (1)$$

Y^*_{ikn} is a latent variable that captures expected net benefit (profit) associated with participation in different value chains and contract farming, measured either at the plot or farm level. Households are expected to participate in a specific value chain or contract farming if the expected net benefit or profit (Y^*_{ikn}) associated with a specific value chain is greater than zero. We assume that this latent variable is a linear combination of various observable household and farm characteristics defined as $\boldsymbol{X}'_{ikn}$ and unobservable factors captured by the error terms, ε_{ikn}. $\boldsymbol{\delta}_n$ represents the vector of parameter estimates associated with the various explanatory variables. Assuming that smallholders participate in cultivation of specific value chains or contract farming if the net benefit (either in profit or utility) from that value chain is greater than zero, we can link these latent unobserved outcomes (Y^*_{ikn}) with the observed sequence of binary participation indicators (Y_{ikn}) as follows:

$$Y_{ikn} = \begin{pmatrix} 1 \; if \;\; Y^*_{ikn} > 0 \\ 0 \; otherwise \end{pmatrix} \qquad (2)$$

Our key interest lies in identification of observable constraints that explain participation in different value chains as well as unobservable factors that trigger interdependencies and hence correlation of the error terms associated with participation decisions. The MVP model generates an error correlation matrix that is informative about the interdependencies between the various value chains and contract farming. A positive correlation suggests potential complementarities while a negative correlation suggests trade-offs or substitutability across value chains and contract farming. For the purpose of tractability, we assume that the sequence of error terms, ε_{ikn}, follow a multivariate normal distribution with mean of 0 and a variance-covariance matrix defined as below[8]:

8 We are applying these functional form assumptions to a relatively large dataset and the normality assumption may not be too strong and hence may not generate spurious results (Baltagi 2001).

$$V = \begin{Bmatrix} 1 & \rho_{12} & \rho_{13} & \rho_{14} \\ \rho_{21} & 1 & \rho_{23} & \rho_{24} \\ \rho_{31} & \rho_{32} & 1 & \rho_{34} \\ \rho_{41} & \rho_{42} & \rho_{43} & 1 \end{Bmatrix} \quad (3)$$

Where we normalized the diagonal elements to assume a value of 1 for identification purposes, which consequently implies that the off-diagonal elements of the covariance matrix hold correlation matrix across unobserved factors associated with smallholders' latent propensities to participate in various value chains. Statistically insignificant elements in the off-diagonal covariance matrix may suggest weak (no) complementarity or substitutability across value chains or contract farming. Given that we are controlling for several observable factors that could affect participation in various value chains and contract farming, we note that the off-diagonal elements of the covariance matrix in equation (3) capture remaining inter-dependencies or substitutability driven by unobserved factors.

For estimation, we rely on maximum likelihood estimation and hence Maximum Simulated Likelihood (MSL) approach (Revelt and Train 1998; Train 2009). We particularly employ the Geweke-Hajivassiliou-Keane smooth recursive conditioning simulator which calculates a likelihood contribution for all replications and averages them (Börsch-Supan and Hajivassiliou 1993). [9] This simulator makes use of sequentially conditioned univariate normal distribution functions.

We also examine the implication of some of the covariates associated with the various value chains and contract farming. The choice of some of these covariates are based on extant literature on the drivers of participation in various value chains and contract farming (Barrett et al. 2012; Otsuka et al. 2016; Bellemare et al. 2022; Meemken and Bellemare 2020). Given the cross-sectional nature of our data and that some of these covariates are likely endogenous, we are careful not to infer causality but interpret the estimated coefficients as associations. These covariates include age and educational level of the farmer, household size, wealth index constructed using various indicators, asset ownership, livestock ownership which represents rural wealth, plot size and the share of plot size relative to total farm size. We also added an indicator variable capturing whether a household practices intercropping and the average village level cost of fertilizer. Additionally, we also include season dummies to control for seasonal differences in the cultivation of the value chains. Some value chains are cultivated in specific seasons due to heat tolerance and soil quality.

To probe the robustness of our results we undertake both plot and household level analysis while also using extensive and intensive margins of participation in the various value chains. To capture the intensive margin of participation in different value chains and contract farming, we compute the share of land allocated to the different value chains as an alternative measure and collapsed this at the household level. We then use seemingly unrelated regression (SUR) models to analyze the correlates of intensive margins of participation in value chains and contract farming. This model also shows the complementarities and trade-offs in the cultivation of these value chains.

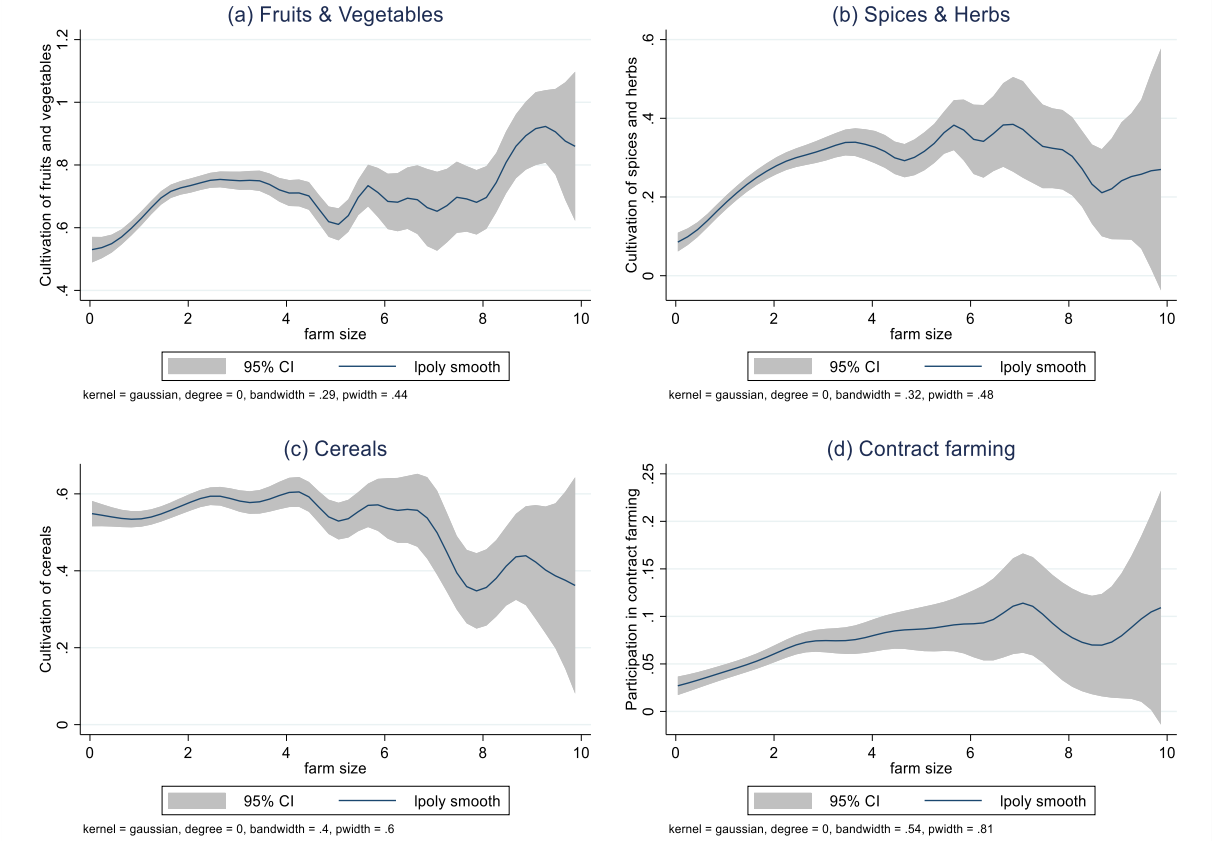
9 We use 100 draws for the estimations. Increasing the number of draws above 100 makes no major difference.

5. RESULTS AND DISCUSSION

5.1 Nonparametric relationships between household characteristics and participation in various value chains and contract farming

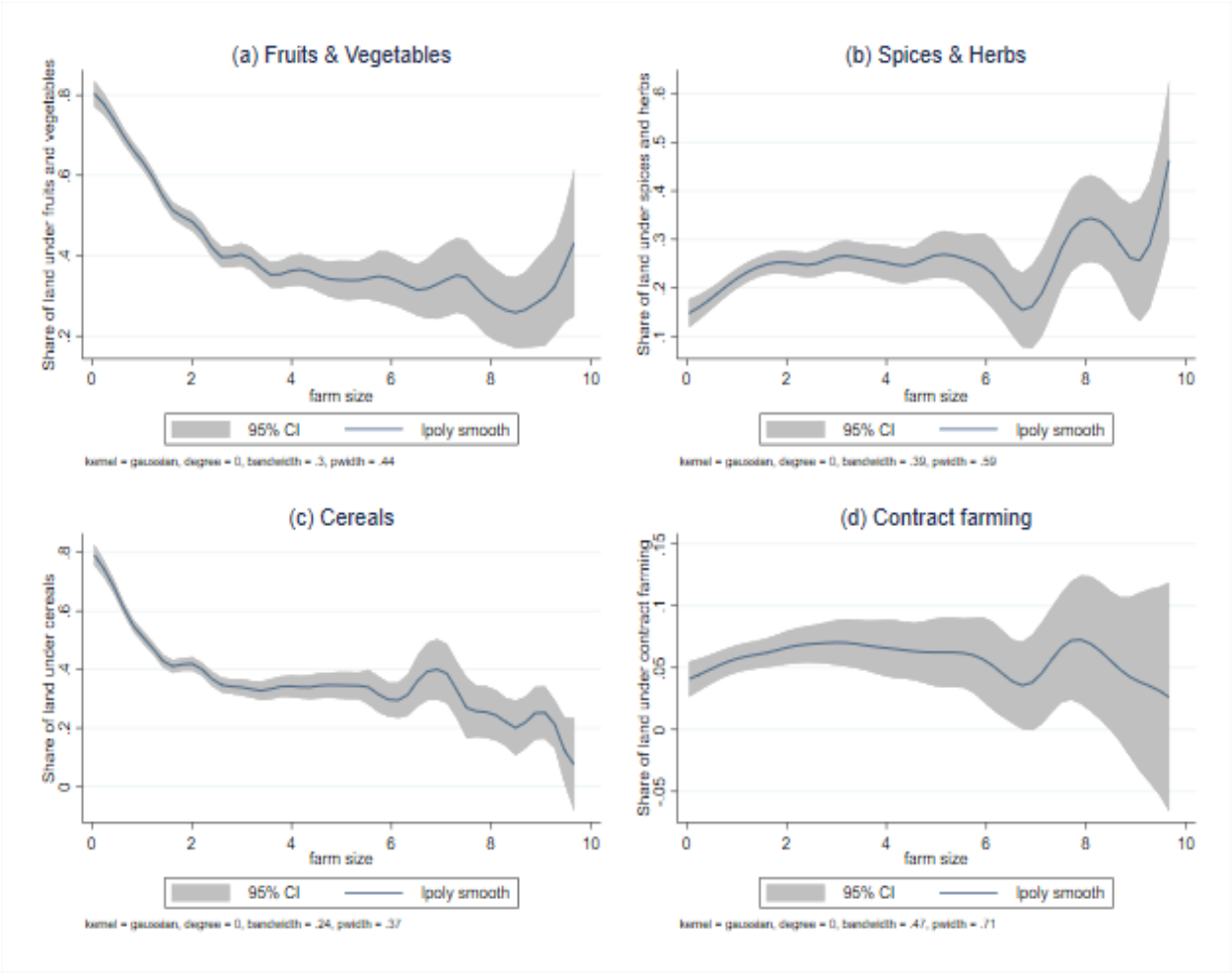
Before estimating more saturated relationships, we start by characterizing some nonparametric bivariate relationships between land size and participation in various value chains and contract farming. This is motivated by previous findings arguing that land scarcity and associated risk and scale of production are major factors inhibiting smallholders' participation in profitable value chains and contract farming (e.g., Holly Wang et al. 2011; Bellemare 2012; Meemken and Bellemare 2020). For this purpose, we assess the relationships between plot (farm) size (or the share of plot size in total farm) and cultivation of these various crops as well as contract farming. For purposes of brevity, we merge fruits and vegetables as well as spices and herbs. We present the relationship for these aggregated groupings and report some of the disaggregated figures in the Appendix. As shown in Figure 1, the relationships between farm size and participation in various value chains and contract farming appear to be nonlinear. For instance, the relationship between farm size and cultivation of spices and herbs appears to be inverse U-shaped, implying a positive and increasing relationship up until some level of farm size and then negative relationship afterwards. Similarly, the relationship between farm size and participation in cereals appears to be positive up to some level of farm size before it reverses to be negative. This is intuitive because for those households with limited land size, food security motives may outweigh profit motives while such trade-offs can change after ensuring some level of food security through cereal production, after which smallholders can aim to maximize profit motives and hence reduce production of cereals (Carletto et al. 2010; Djurfeldt and Djurfeldt 2013).

Figure 1: Non-parametric relationship between farm size and participation in different value chains and contract farming



The relationships between intensive margin of participation in value chains, measured by the share of farm size allocated to a specific value chain, and total farm size are slightly distinct (Figure 2). We can interpret these shares as an indicator of risk (Feder and O'Mara 1981), such that large shares would imply the farmer does not have other land to diversify production. These relationships show that households with larger farm size are more likely to allocate smaller share of their land on less profitable value chains such as cereals and vegetables while devoting larger share of their land on high-value crops such as spices and herbs. All these insights are suggestive of the fact that smallholders in Egypt face trade-offs between ensuring food security and maximizing profit and land plays a major factor in moderating this trade-off. We formally test these relationships in our parametric estimations.

Figure 2: Non-parametric relationship between farm size and share of land under various value chains and contract farming (household level)



Besides land endowment, farm experience and associated risk-taking behavior may affect investment in profitable value chains and contract farming. The non-parametric relationships in Figure 3, despite some nonlinear patterns, broadly suggest that older farmers are less likely to allocate larger share of their land on profitable value chains such as fruits and vegetables as well as spices and herbs. The relationship between the age of household head and contract farming shows similar pattern. The inverse relationship is particularly more pronounced after around 45 years where the share of land allocated for contract farming clearly decreases as age increases. This could be explained by the fact that older farmers may be more risk averse to increase the share of land under these value chains. Older farmers have been shown to be more risk averse than younger farmers (Nielsen et al. 2013). This finding has some important implications for informing effective policies to target and encourage smallholders join profitable value chains in Egypt and other comparable contexts. Intuitively, this implies that targeting and encouraging young farmers transit to market-oriented production may be cost-effective.

Figure 3: Non-parametric relationship between age of household head and participation in value chains and contract farming

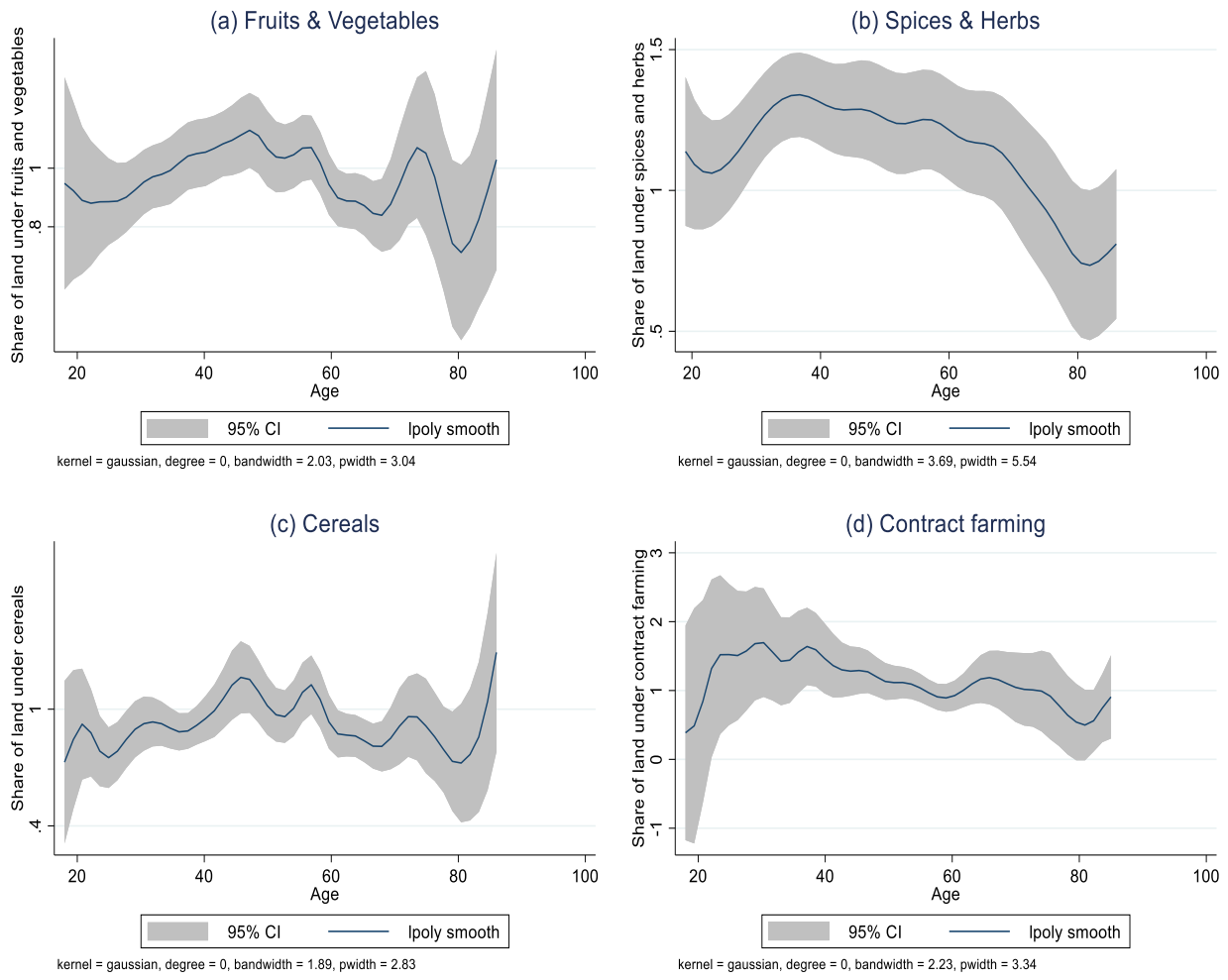
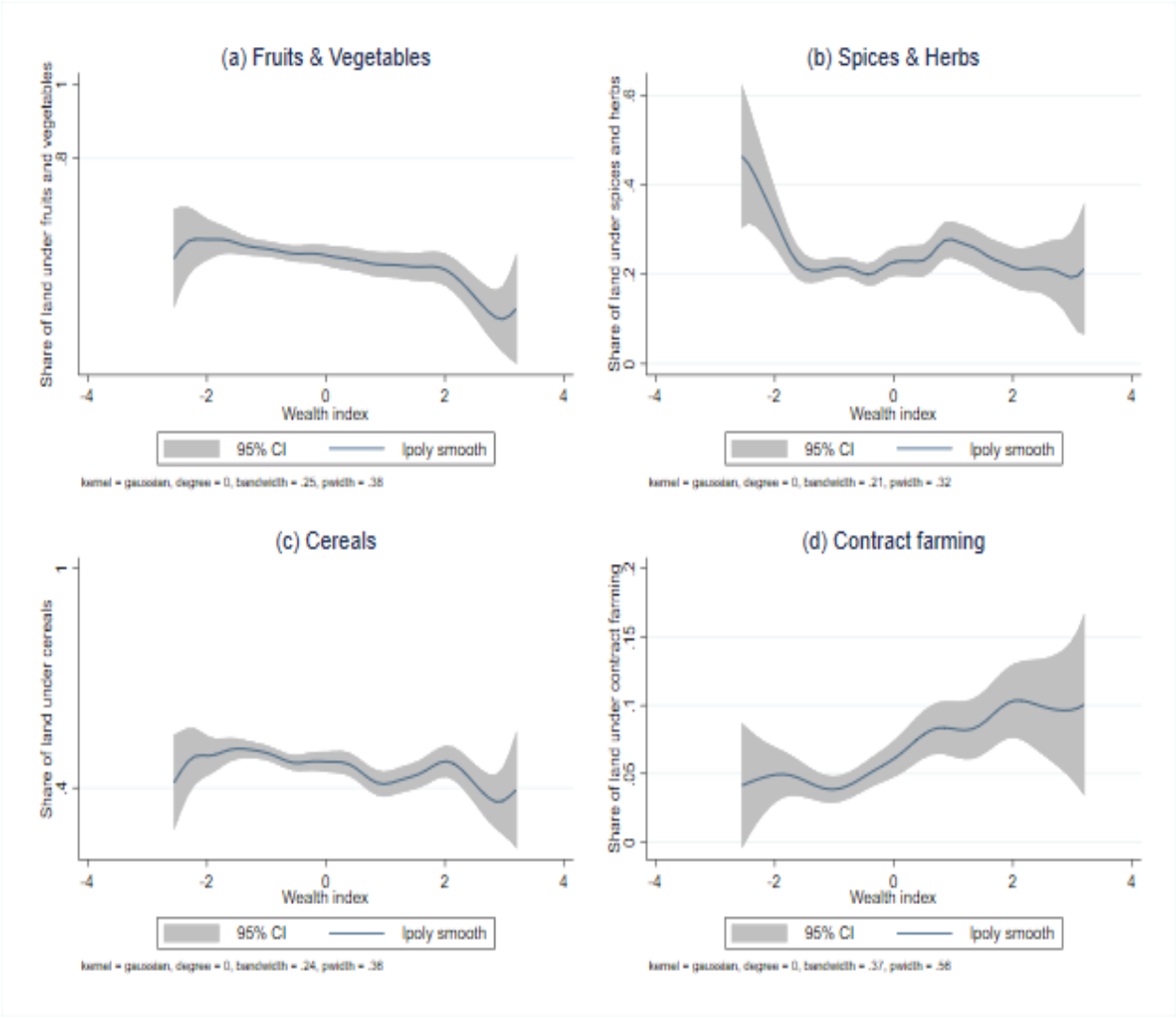


Figure 4 shows non-parametric relationships between wealth and the share of land under the various value chains and contract farming. We observe an inverse relationship between household wealth and share of farm allocated for low-value crops, highlighting that as wealth increases, the share of land allocated to cereals decline while the share of land under contract farming increases. The positive relationship between households' wealth and participation in contract farming suggests that the poor may also be excluded from contract farming by virtue of their limited wealth endowment. Given that wealth is usually positively associated with farm size, this linear relationship is expected.

Figure 4: Non-parametric relationship between wealth and share of land under value chains and contract farming



5.2 Correlates of participation in various value chains and contract farming

Tables 2 and 3 present the results characterizing farmers' participation in various value chains and contract farming as a function of household socio-economic and farm characteristics. These results come from the multivariate probit (MVP) model specified in equations (1)-(3). Following the nonlinear patterns detected in Figure 1-4, we allow higher-order polynomial terms in each specification. In Table 2 we report plot-level analysis while Table 3 uses household-level participation rates. In this sub-section we discuss the observable characteristics explaining households' propensity to participate in various value chains while Section 5.3 describes the correlation driven by unobservable factors. Younger farmers are more likely to participate in high-value value chains than their older counterparts, particularly in cultivating spices and herbs. Younger farmers may be more risk takers and open to new technologies. Thus, their relatively higher participation rates in the cultivation of spices and herbs, which are profitable, are not surprising. Age has been shown to be negatively associated with participation in high-value value chains in other context (Simmons et al. 2005; Bellemare 2012; Bellemare and Lim 2018). The implication of education appears to be mixed and varying across the plot-level and household-level analyses. Those

farmers with secondary and above education are more likely to participate in contract farming and high-value chains. This finding is intuitive and corroborates previous findings about the role of education and information on participation in contract farming (Bellemare and Lim 2018; Mishra et al. 2018).

Based on the extant literature, plot and farm sizes appears to be an important variable stirring and/or limiting participation in contract farming and various value chains (Wang et al. 2014a). While we find large farm sizes to be associated with cultivation of spices and herbs, resource poor farmers with small farm sizes are more likely to be participate in low-value chains such as cereals. Our findings here provide some support to a part of the literature[10] that has established that high-value value chains and contract farming may be scale dependent and positively biased towards medium and large farms (Holly Wang et al. 2011; Bellemare 2012; Meemken and Bellemare 2020). This is consistent with the notion that large farms may increase the returns to investments in high-value value chains and reduce transaction cost incurred by the contractor (Swinnen and Kuijpers 2020). However, pushing smallholder farmers to contract farming especially through production contracts may have important implications for increasing productivity and ensuring inclusive development (Maertens and Vande Velde 2017; Swinnen and Kuijpers 2020). We also observe that there exists a threshold point beyond which increases in plot or farm size may not matter for participation in high value chains. The insights here speak to a non-monotonic relationship and are consistent with the nonparametric estimations where we observe nonlinear relationships between plot size and participation in value chains.

Livestock ownership is positively associated with the cultivation of cereals as well as fruits and vegetables but inversely associated with the cultivation of spices and herbs. Two insights may explain this: specialization and diversification. Farmers who cultivate cereals as well as fruits and vegetables may also keep livestock as a way of diversifying their livelihood options and choices. Commercialization of low-value crops in Ethiopia has been shown to increase livestock accumulation on smallholder farms (Tabe-Ojong et al. 2022). In many rural communities, livestock represents considerable social wealth and status. Households have also been shown to use livestock as buffers in times of unexpected and unprecedented shocks (Verpoorten 2009). For the case of spices and herbs, we find a negative association which may hint again at some form of specialization. Given that these activities may be directly welfare increasing on many fronts, households may prefer to specialize to ensure maximal gains.

Finally, households' socio-economic status, as captured by wealth index and ownership of productive assets, is positively associated with participation in high-value crops and contract farming. This is intuitive given that participation in some of these high-value value chains can be capital-intensive and risky.

10 Other studies like Miyata et al. (2009) find little or no evidence that larger farms are likely to get contracted.

Table 2: MVP estimates of value chain participation and contracts (plot-level analysis)

	(1) Fruits and vegetables	(2) Spices and herbs	(3) Cereals	(4) Contract farming
Age of head (years)	-0.018	-0.041***	0.012	-0.006
	(0.012)	(0.013)	(0.010)	(0.015)
Age (squared)	0.000*	0.000***	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Head is male (1/0)[11]	0.977***	0.197	0.217	-----
	(0.286)	(0.242)	(0.179)	
Primary education (1/0)	0.489***	0.186**	0.251***	0.017
	(0.095)	(0.075)	(0.060)	(0.110)
Complete secondary education (1/0)	0.450***	0.239***	0.239***	0.158*
	(0.081)	(0.060)	(0.059)	(0.084)
Higher education (1/0)	0.581***	0.175**	0.341***	0.172**
	(0.086)	(0.070)	(0.049)	(0.081)
Household size (number)	0.035**	0.028*	0.006	0.029
	(0.017)	(0.017)	(0.012)	(0.019)
Plot size (feddan)	-0.147***	0.107***	-0.128***	0.040
	(0.049)	(0.033)	(0.030)	(0.041)
Plot size (squared)	0.004**	-0.002*	0.004***	-0.004
	(0.002)	(0.001)	(0.001)	(0.003)
Tropical livestock units	0.060***	-0.089***	0.065***	-0.038*
	(0.023)	(0.024)	(0.018)	(0.022)
Wealth index	0.065	-0.081**	0.012	0.112***
	(0.043)	(0.041)	(0.031)	(0.037)
Productive asset index	0.136***	0.015	-0.018	0.057
	(0.038)	(0.042)	(0.035)	(0.048)
Fertilizer cost (EGP/feddan)	0.070	-0.092	0.001	-0.017
	(0.104)	(0.089)	(0.042)	(0.050)
Intercropping (1/0)	0.319***	-0.014	-0.123*	0.146*
	(0.066)	(0.074)	(0.065)	(0.078)
Land ownership (1/0)	-0.151**	0.124*	-0.018	-0.186**
	(0.062)	(0.064)	(0.051)	(0.081)
Constant	-1.396**	-0.046	-0.432	-1.757***
	(0.633)	(0.612)	(0.384)	(0.497)
Season dummy	Yes	Yes	Yes	Yes
Observations	5,710	5,710	5,710	5,710

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

11 Almost all households in our sample are male headed (see Table 1). Thus, for some of the outcomes with limited variation across male and female households, this indicator variable drops from the regression.

Table 3 MVP estimates of value chain participation and contracts (household-level analysis)

	(1)	(2)	(3)	(4)
	Fruits and vegetables	**Spices and herbs**	**Cereals**	**Contract farming**
Age of head (years)	-0.043	-0.061***	0.003	-0.024
	(0.037)	(0.020)	(0.021)	(0.018)
Age (squared)	0.001	0.001***	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Head is male (1/0)	-----	0.098	-0.255	0.695
		(0.193)	(0.214)	(0.469)
Primary education (1/0)	-0.146	0.032	0.112	-0.233
	(0.176)	(0.130)	(0.127)	(0.184)
Complete secondary education (1/0)	0.359*	-0.064	0.051	-0.075
	(0.189)	(0.098)	(0.134)	(0.130)
Higher education (1/0)	-0.003	-0.082	0.100	0.035
	(0.118)	(0.085)	(0.162)	(0.138)
Household size (number)	-0.003	0.032*	0.011	0.034
	(0.026)	(0.019)	(0.024)	(0.021)
Farm size (feddan)	-0.459***	0.258***	-0.281***	-0.004
	(0.084)	(0.082)	(0.074)	(0.058)
Farm size (squared)	0.031***	-0.010**	0.019***	-0.002
	(0.007)	(0.004)	(0.006)	(0.004)
Tropical livestock units	0.222***	-0.018	0.214***	0.019
	(0.061)	(0.028)	(0.042)	(0.031)
Wealth index	0.067	-0.010	-0.019	0.197***
	(0.086)	(0.065)	(0.042)	(0.051)
Productive asset index	0.269***	0.132**	0.011	0.114*
	(0.061)	(0.054)	(0.056)	(0.059)
Fertilizer cost (EGP/feddan)	0.203**	-0.138	0.174*	-0.073
	(0.096)	(0.125)	(0.089)	(0.070)
Intercropping (1/0)	0.489***	-0.140	0.704***	0.271**
	(0.106)	(0.143)	(0.120)	(0.128)
Land ownership (1/0)	0.054	0.102	0.199***	-0.300***
	(0.114)	(0.083)	(0.059)	(0.088)
Constant	1.183	0.866	-1.099	-0.902
	(0.971)	(0.804)	(0.673)	(0.699)
Season dummy	Yes	Yes	Yes	Yes
Observations	2,237	2,237	2,237	2,237

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

In Table 4 we characterize the intensive margin of participation in different value chains using the share of land allocated for each value chain. Thus, we estimate a seemingly unrelated regression (SUR) to jointly estimate and model household-level intensive margin of participation in various value chains. The results in Table 4 broadly confirm those in Table 2 and 3. Older farmers are less likely to allocate a larger share of their land to high-value value chains such as spices and herbs. Similarly, households owning larger farms are more likely to allocate larger (smaller) share of their land on high(low)-value crops. Finally, wealthier households are less likely to allocate a larger share of their land on both low-value crops

such as cereals. On the other hand, wealthier households are more likely to allocate a larger share of their land to contract farming.

Table 4: SUR estimates of the share of value chain participation (household level)

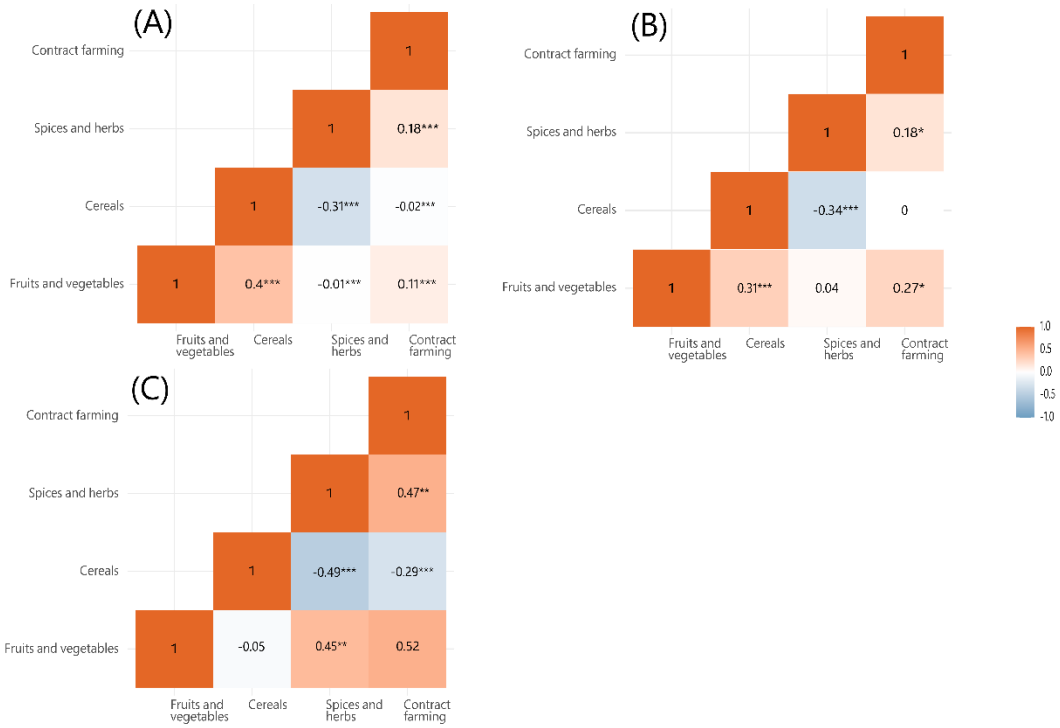
	(1)	(2)	(3)	(4)
	Fruits and vegetables	Spices and herbs	Cereals	Contract farming
Age of head (years)	0.005	-0.009***	0.003	-0.001
	(0.003)	(0.003)	(0.003)	(0.002)
Age (squared)	-0.000	0.000**	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Head is male (1/0)	-0.096**	0.007	-0.085**	0.023
	(0.041)	(0.043)	(0.041)	(0.027)
Primary education (1/0)	0.026	0.024	0.040	-0.006
	(0.027)	(0.028)	(0.027)	(0.018)
Secondary education (1/0)	0.037*	-0.020	0.053**	-0.008
	(0.022)	(0.022)	(0.022)	(0.014)
Higher education (1/0)	0.001	-0.011	0.020	-0.000
	(0.020)	(0.021)	(0.020)	(0.013)
Household size (number)	-0.010***	0.001	-0.004	0.001
	(0.003)	(0.003)	(0.003)	(0.002)
Farm size(feddan)	-0.027***	0.068***	-0.047***	0.007
	(0.008)	(0.008)	(0.008)	(0.005)
Farm size (squared)	0.001**	-0.003***	0.004***	-0.000
	(0.001)	(0.001)	(0.001)	(0.000)
Tropical livestock units	-0.008**	-0.017***	0.001	0.001
	(0.004)	(0.004)	(0.004)	(0.003)
Wealth index	-0.017***	-0.010*	-0.016***	0.016***
	(0.006)	(0.006)	(0.006)	(0.004)
Productive asset index	-0.039***	0.007	-0.043***	0.008
	(0.008)	(0.008)	(0.008)	(0.005)
Fertilizer cost (EGP/feddan)	-0.021***	-0.037***	-0.018***	-0.013***
	(0.006)	(0.006)	(0.006)	(0.004)
Intercropping (1/0)	-0.147***	-0.113***	-0.082***	0.005
	(0.013)	(0.014)	(0.013)	(0.009)
Land ownership (1/0)	-0.047***	-0.025	-0.009	-0.035***
	(0.015)	(0.016)	(0.015)	(0.010)
Season dummy	-0.139***	0.109**	0.096**	-0.040
	(0.041)	(0.043)	(0.041)	(0.027)
Constant	0.988***	0.572***	0.574***	0.189***
	(0.098)	(0.103)	(0.099)	(0.064)
Season dummy	Yes	Yes	Yes	Yes
Observations	2,237	2,237	2,237	2,237

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

5.3 Interdependencies across value chains and contract farming

This section presents error correlation results generated from the MVP models which estimate conditional error correlation coefficients associated with various value chains and contract farming. This joint estimation captures additional unobservable correlations associated with these decisions. Figure 5 shows these unobservable correlations between the various value chains and contract farming. The first panel (A) shows estimates based on plot-level estimation while the second panel (B) provides estimates using household- level analysis. Panel C shows the interdependencies using the share of land under each value chain and contract farming. As highlighted earlier, but worth repeating, a positive correlation implies complementarity while a negative correlation implies substitutability. The insights from these three models are again broadly consistent. The complementarity and substitutability across various value chains is sometimes stronger at the plot-level while the reverse is observed for some combination of value chains. This is likely to arise from the potential variation in the drivers of these complementarities at plot level and farm level. For example, complementarities at plot level are likely to be driven by potential biophysical factors that may affect intercropping patterns and choices. For example, vegetables are easy to intercrop them with cereal production while this appears to be unlikely for spices and herbs.

Figure 5 Complementarities and substitutability in value chains



Farmers who cultivate these high-value crops are more likely to participate in contract farming and this is likely to prevail at plot and household level. Four reasons could explain this relationship (Swinnen et al. 2010). First, transaction costs associated with market access of these crops may be substantially high given that the downstream segment of the chain may have limited buyers and sellers. Contract farming may have the ability to drive up prices in this scenario. Second, these high-value value chains offer significant opportunities for value addition and product upgrading. This makes it possible to offer price premiums to farmers which are important in reducing opportunistic behaviors. Third, high-value value chains

require substantial amounts of inputs like fertilizers and pesticides which may often be provided through contracts. Moreover, training, and technical assistance are an integral aspect of most contracts to ensure that farmers follow recommended agronomic practices to maximize their yields. Finally, these high-value value chains are usually very perishable, and the absence of storage opportunities makes contracting attractive. In the context of Egypt, the government usually offers price guarantee and price support mechanisms for cereal crops such as wheat which may affect farmers' crop choices and participation in contract farming.

Between the high-value and low-value crops, we observe significant substitutability. Specifically, major cereals such as wheat and maize are less likely to be cultivated on plots where high-value crops are cultivated. Relatedly, farmers who cultivate low-value crops are less likely to participate in contract farming. This is an important finding with implications for policy as this suggests some form of specialization. Households may prefer to specialize in categories of value chains depending on specific welfare objectives. Households that prefer to increase their income streams may get into high-value crops. The cultivation of high-value crops has been shown to be associated with increases in smallholder farmers and poverty reduction (Miyata et al. 2009 ; Maertens and Swinnen 2009; Bellemare 2012; Wang et al. 2014a; Wang et al. 2014b; Maertens and Vande Velde 2017; Ton et al. 2018 ; Meemken and Bellemare 2020 ; Arouna et al. 2021 ; Otsuka et al. 2016). However, small-scale farmers are usually excluded from these value chains given their resource constraints and other structural factors (Isager et al. 2018; Ton et al. 2018). This may explain their low participation in high-value and profitable value chains. Moreover, these resource-poor farmers may be more interested in improving food consumption and relaxing their household food demands than maximizing profits. Participation in contract farming in a common staples like rice and maize have been shown to increase food security (Bellemare and Novak 2017; Soullier and Moustier 2018). This is not to say that there are no overlaps in ultimate decisions to either cultivate high-value or low-value crops. It has been established that the cultivation of low-value crops may increase crop diversity which may be used to improve consumption, with food production beyond consumption being sold in output markets (Sibhatu et al. 2015; Koppmair et al. 2017; Ecker 2018; Sibhatu and Qaim 2018). On the other hand, the cultivation of high-value crops may increase the purchasing power of households, enabling them to purchase food and improve their food security (Mishra et al. 2018).

The finding about the strong substitutability between the cultivation of low-value crops and contract farming reinforces some aspects of the relationship between high-value value chains and contract farming, given that most contracts are established for high-value horticultural and cash crops. However, contract farming for low-value crops could also generate welfare implications and contribute to poverty reduction given that they can be more inclusive and could reach more resource poor farmers (Miyata et al. 2009). Contract farming, especially interlinked contracts, may not work or be susceptible to a plethora of enforcement issues for low-value crops such as cereals (Swinnen et al. 2010). Contract farming in cereals may lead to significant hold-up and enforcement constraints given that they are easy to sell given numerous buyers and sellers. Moreover, they are easier to store than high-value crops such as fruits and vegetables. This storage feature may open up to opportunistic behaviors such as side selling (Ragasa et al. 2018). That said, given that contract farming may provide input support to farmers especially in uncertain situations where prices may increase, contract farming in cereals may be a necessary option given the high input requirements for cultivating many cereals. Contracting in rice have been shown to reduce food insecurity by mitigating price seasonality (Soullier and Moustier 2018). Besides these food security impacts, contracting in rice also increases income (Maertens and Vande Velde 2017; Arouna et al. 2021) although there remain concerns about its profitability (Ragasa et al. 2018).

6. CONCLUSION AND POLICY IMPLICATIONS

Using unique plot level data from irrigated agriculture in Egypt and a multivariate probit (MVP) model, we examine smallholders' participation in various value chains and contract farming while also estimating potential complementarities between various value chains and contract farming. We identify several important observable factors that reinforce and limit the participation of farmers in various value chains and contract farming. We find suggestive evidence that smallholders in Egypt face a trade-off between ensuring food security to their households and maximizing profit and land endowment plays a major factor in moderating this trade-off. Farmers with limited land resources are more likely to devote larger share of their land on low-value crops such as cereals while this pattern weakens with increasing land size. This suggests until some level of land resources food security goals may dominate profit motives while this reverses after ensuring food security goals are achieved. Younger and wealthier farmers are more likely to participate in production of high-value crops such as spices and herbs as well as contract farming. We also document strong complementarities between participation in high-value value chains and contract farming. Particularly, farmers who cultivate high-value crops are more likely to be engaged in contract farming. Finally, we show that land scarcity is associated with lower (higher) participation in profitable (low value) value chains.

These findings have important policy implications, pointing to the direction that addressing smallholders' binding constraints, including land scarcity, can encourage participation in profitable value chains and contract farming. Intuitively, these findings imply that addressing smallholders' binding constraints, including risk and access to land, can encourage participation in profitable value chains and contract farming. Our findings offer suggestive evidence that may serve in targeting smallholders to join profitable value chains in Egypt and other comparable contexts. For example, despite the limited land resources young farmers usually own, they are more likely to participate in high-value and profitable value chains, which insinuates that supporting young farmers get access to land and financial resources may increase their participation in profitable value chains and contract farming. As land resources in most MENA regions are scarce, various land reclamation efforts may need to properly target young. Given the seeming marginalization that young and smallholder farmers may face even when such reclamation policies are enforced, it is important that land redistribution programs target those who can generate maximum returns to limited land and water resources. Such programs may also encourage and empower women who usually have little access and control over agricultural land.

Another important finding relevant for policy is the apparent trade-off between high-value and low-value crops. While the high-value crops are more profitable with greater abilities to increase welfare and reduce poverty, the low-value crops may be more inclusive and with greater implications for household food security. This is not to mean that high-value crops are correlated with food insecurity as incomes from the cultivation of these crops can be used to relax household liquidity constraints households may be facing. Such incomes could be used to purchase diverse foods and improve food security and dietary diversity. That said, these are important trade-offs with varying implications across farmers with varying land and wealth. Thus, policies geared at reducing the binding constraints farmers are facing may trigger their participation in high-value crops such that both value chains may be complementary.

We admittedly recognize that our analysis is implicitly associational, although we have controlled for many confounding factors that may explain smallholders' participation in various value chains. Nevertheless, our findings are noteworthy and contribute to explain the disappointingly low participation of smallholder farmers in profitable value chains and contract farming in a region that is contextually different

from many farming systems in sub-Saharan Africa. That said, more analyses may be needed to assess the external validity of our findings.

ABOUT THE AUTHORS

Martin Paul Jr. Tabe-Ojong is an Associate Research Fellow in the Development Strategy and Governance Division at IFPRI, based in Cairo. **Kibrom A. Abay** is a Research Fellow in the Development Strategy and Governance Division and Program Leader of the Egypt Strategy Support Program of the International Food Policy Research Institute (IFPRI), based in Cairo.

Corresponding author: m.p.tabe-ojong@cgiar.org

ACKNOWLEDGMENTS

We gratefully acknowledge the financial support of the United States Agency for International Development (USAID) through the project “Evaluating Impact and Building Capacity” (EIBC) that is implemented by the International Food Policy Research Institute (IFPRI). The information provided in this paper is not official U.S. government information and does not represent the views or positions of the USAID or the U.S. Government. Any opinions stated herein are those of the authors and are not necessarily representative of or endorsed by IFPRI.

REFERENCES

Abay, Kibrom A.; Abdelfattah, Lina; El-Enbaby, Hoda; Mai, Mahmoud; Breisinger, Clemens (2022a): Plot size and sustainable input intensification in smallholder irrigated agriculture: Evidence from Egypt. In *Agricultural Economics* 53, no. 5 (2022): 792-810.

Abay, Kibrom A.; Breisinger, Clemens; Glauber, Joseph W.; Kurdi, Sikandra; Laborde Debucquet, David; Siddig, Khalid (2022b): The Russia-Ukraine Crisis: Implications for Global and Regional Food Security and Potential Policy Responses. International Food Policy Research Institute. Washington, DC (MENA Working Paper, 39).

Abebe, Gumataw K.; Bijman, Jos; Kemp, Ron; Omta, Onno; Tsegaye, Admasu (2013): Contract farming configuration: Smallholders’ preferences for contract design attributes. In *Food Policy* 40, pp. 14–24. DOI: 10.1016/j.foodpol.2013.01.002.

Aboulnaga, A.; Siddik, I.; Megahed, W.; Salah, E.; Ahmed, S.; Nageeb, R. et al. (2017): Study on small-scale family farming in the Near East and North Africa region. Focus country: Egypt. Rome, Italy: FAO.

Arndt, Channing; Davies, Rob; Gabriel, Sherwin; Harris, Laurence; Makrelov, Konstantin; Robinson, Sherman et al. (2020): Covid-19 lockdowns, income distribution, and food security: An analysis for South Africa. In *Global food security* 26, p. 100410. DOI: 10.1016/j.gfs.2020.100410.

Arouna, Aminou; Michler, Jeffrey D.; Lokossou, Jourdain C. (2021): Contract farming and rural transformation: Evidence from a field experiment in Benin. In *Journal of development economics* 151, p. 102626. DOI: 10.1016/j.jdeveco.2021.102626.

Ashraf, Nava; Giné, Xavier; Karlan, Dean (2009): Finding Missing Markets (and a Disturbing Epilogue): Evidence from an Export Crop Adoption and Marketing Intervention in Kenya. In *American Journal of Agricultural Economics* 91 (4), pp. 973–990. DOI: 10.1111/j.1467-8276.2009.01319.x.

Ba, Hélène A.; Mey, Yann de; Thoron, Sylvie; Demont, Matty (2019): Inclusiveness of contract farming along the vertical coordination continuum: Evidence from the Vietnamese rice sector. In *Land Use Policy* 87, p. 104050. DOI: 10.1016/j.landusepol.2019.104050.

Baltagi, Badi H. (2001): Econometric Analysis of Panel Data: John Wiley.

Barrett, Christopher B. (2008): Smallholder market participation: Concepts and evidence from eastern and southern Africa. In *Food Policy* 33 (4), pp. 299–317. DOI: 10.1016/j.foodpol.2007.10.005.

Barrett, Christopher B.; Bachke, Maren E.; Bellemare, Marc F.; Michelson, Hope C.; Narayanan, Sudha; Walker, Thomas F. (2012): Smallholder Participation in Contract Farming: Comparative Evidence from Five Countries. In *World Development* 40 (4), pp. 715–730. DOI: 10.1016/j.worlddev.2011.09.006.

Bellemare, Marc F. (2012): As You Sow, So Shall You Reap: The Welfare Impacts of Contract Farming. In *World Development* 40 (7), pp. 1418–1434. DOI: 10.1016/j.worlddev.2011.12.008.

Bellemare, Marc F.; Bloem, Jeffrey R. (2018): Does contract farming improve welfare? A review. In *World Development* 112, pp. 259–271. DOI: 10.1016/j.worlddev.2018.08.018.

Bellemare, Marc F.; Bloem, Jeffrey R.; Lim, Sunghun (2022): Producers, consumers, and value chains in low- and middle-income countries. In *Handbook of Agricultural Economics*.

Bellemare, Marc F.; Lim, Sunghun (2018): In All Shapes and Colors: Varieties of Contract Farming. In *Applied Economic Perspectives and Policy* 40 (3), pp. 379–401. DOI: 10.1093/aepp/ppy019.

Bellemare, Marc F.; Novak, Lindsey (2017): Contract Farming and Food Security. In *American Journal of Agricultural Economics* 99 (2), pp. 357–378. DOI: 10.1093/ajae/aaw053.

Biggeri, Mario; Carraro, Alessandro; Ciani, Federico; Romano, Donato (2022): Disentangling the impact of a multiple-component project on SDG dimensions: The case of durum wheat value chain development in Oromia (Ethiopia). In *World Development* 153, p. 105810. DOI: 10.1016/j.worlddev.2021.105810.

Börsch-Supan, Axel; Hajivassiliou, Vassilis A. (1993): Smooth unbiased multivariate probability simulators for maximum likelihood estimation of limited dependent variable models. In *Journal of Econometrics* 58 (3), pp. 347–368. DOI: 10.1016/0304-4076(93)90049-B.

Boyd, Chris M.; Bellemare, Marc F. (2020): The Microeconomics of Agricultural Price Risk. In *Annu. Rev. Resour. Econ.* 12 (1), pp. 149–169. DOI: 10.1146/annurev-resource-100518-093807.

Cappellari, Lorenzo; Jenkins, Stephen P. (2003): Multivariate Probit Regression using Simulated Maximum Likelihood. In *The Stata Journal* 3 (3), pp. 278–294. DOI: 10.1177/1536867x0300300305.

Carletto, Calogero; Kirk, Angeli; Winters, Paul C.; Davis, Benjamin (2010): Globalization and Smallholders: The Adoption, Diffusion, and Welfare Impact of Non-Traditional Export Crops in Guatemala. In *World Development* 38 (6), pp. 814–827. DOI: 10.1016/j.worlddev.2010.02.017.

Chavas, J. P. (Ed.) (2019): Role of risk and uncertainty in agriculture. With assistance of Gail L. Cramer, Krishna P. Paudel, Andrew Schmitz. Abingdon, Oxon, New York, NY: Routledge (The Routledge Handbook of Agricultural Economics.).

Djurfeldt, Agnes Andersson; Djurfeldt, Göran (2013): Structural Transformation and African Smallholders: Drivers of Mobility within and between the Farm and Non-farm Sectors for Eight Countries. In *Oxford Development Studies* 41 (3), pp. 281–306. DOI: 10.1080/13600818.2013.817550.

Ecker, Olivier (2018): Agricultural transformation and food and nutrition security in Ghana: Does farm production diversity (still) matter for household dietary diversity? In *Food Policy* 79, pp. 271–282. DOI: 10.1016/j.foodpol.2018.08.002.

FAO (2016): AQUASTAT Country Profile – Egypt. Food and Agriculture Organization (FAO). Rome.

Feder, Gershon; O'Mara, Gerald T. (1981): Farm Size and the Diffusion of Green Revolution Technology. In *Economic Development and Cultural Change* 30 (1), pp. 59–76. DOI: 10.1086/452539.

Fuglie, Keith; Dhehibi, Boubaker; El Shahat, Ali Ahmed Ibrahim; Aw-Hassan, Aden (2021): Water, Policy, and Productivity in Egyptian Agriculture. In *American Journal of Agricultural Economics* 103 (4), pp. 1378–1397. DOI: 10.1111/ajae.12148.

Holly Wang, H.; Zhang, Yanping; Wu, Laping (2011): Is contract farming a risk management instrument for Chinese farmers? In *China Agricultural Economic Review* 3 (4), pp. 489–505. DOI: 10.1108/17561371111192347.

Isager, Lotte; Fold, Niels; Nsindagi, Thobias (2018): The Post-Privatization Role of Out-growers' Associations in Rural Capital Accumulation: Contract Farming of Sugar Cane in Kilombero, Tanzania. In *J Agrar Change* 18 (1), pp. 196–213. DOI: 10.1111/joac.12197.

Key, Nigel; Sadoulet, Elisabeth; Janvry, Alain de (2000): Transactions Costs and Agricultural Household Supply Response. In *American Journal of Agricultural Economics* 82 (2), pp. 245–259. DOI: 10.1111/0002-9092.00022.

Koppmair, Stefan; Kassie, Menale; Qaim, Matin (2017): Farm production, market access and dietary diversity in Malawi. In *Public health nutrition* 20 (2), pp. 325–335. DOI: 10.1017/S1368980016002135.

Maertens, Miet; Swinnen, Johan F.M. (2009): Trade, Standards, and Poverty: Evidence from Senegal. In *World Development* 37 (1), pp. 161–178. DOI: 10.1016/j.worlddev.2008.04.006.

Maertens, Miet; Vande Velde, Katrien (2017): Contract-farming in Staple Food Chains: The Case of Rice in Benin. In *World Development* 95, pp. 73–87. DOI: 10.1016/j.worlddev.2017.02.011.

Meemken, Eva-Marie; Bellemare, Marc F. (2020): Smallholder farmers and contract farming in developing countries. In *Proceedings of the National Academy of Sciences of the United States of America* 117 (1), pp. 259–264. DOI: 10.1073/pnas.1909501116.

Minot, Nicholas; Sawyer, Bradley (2016): Contract farming in developing countries: Theory, practice, and policy implications. Research Institute, International Food Policy. Washington, DC.

Mishra, Ashok K.; Kumar, Anjani; Joshi, Pramod K.; D'Souza, Alwin (2018): Production Risks, Risk Preference and Contract Farming: Impact on Food Security in India. In *Applied Economic Perspectives and Policy* 40 (3), pp. 353–378. DOI: 10.1093/aepp/ppy017.

Miyata, Sachiko; Minot, Nicholas; Hu, Dinghuan (2009): Impact of Contract Farming on Income: Linking Small Farmers, Packers, and Supermarkets in China. In *World Development* 37 (11), pp. 1781–1790. DOI: 10.1016/j.worlddev.2008.08.025.

Narayanan, Sudha (2014): Profits from participation in high value agriculture: Evidence of heterogeneous benefits in contract farming schemes in Southern India. In *Food Policy* 44, pp. 142–157. DOI: 10.1016/j.foodpol.2013.10.010.

Nielsen, Thea; Keil, Alwin; Zeller, Manfred (2013): Assessing farmers' risk preferences and their determinants in a marginal upland area of Vietnam: a comparison of multiple elicitation techniques. In *Agricultural Economics* 44 (3), pp. 255–273. DOI: 10.1111/agec.12009.

Ochieng, Dennis O.; Veettil, Prakashan C.; Qaim, Matin (2017): Farmers' preferences for supermarket contracts in Kenya. In *Food Policy* 68, pp. 100–111. DOI: 10.1016/j.foodpol.2017.01.008.

Otsuka, Keijiro; Nakano, Yuko; Takahashi, Kazushi (2016): Contract Farming in Developed and Developing Countries. In *Annu. Rev. Resour. Econ.* 8 (1), pp. 353–376. DOI: 10.1146/annurev-resource-100815-095459.

Ragasa, Catherine; Lambrecht, Isabel; Kufoalor, Doreen S. (2018): Limitations of Contract Farming as a Pro-poor Strategy: The Case of Maize Outgrower Schemes in Upper West Ghana. In *World Development* 102, pp. 30–56. DOI: 10.1016/j.worlddev.2017.09.008.

Renkow, Mitch; Hallstrom, Daniel G.; Karanja, Daniel D. (2004): Rural infrastructure, transactions costs and market participation in Kenya. In *Journal of development economics* 73 (1), pp. 349–367. DOI: 10.1016/j.jdeveco.2003.02.003.

Revelt, David; Train, Kenneth (1998): Mixed Logit with Repeated Choices: Households' Choices of Appliance Efficiency Level. In *Review of Economics and Statistics* 80 (4), pp. 647–657. DOI: 10.1162/003465398557735.

Sibhatu, Kibrom T.; Krishna, Vijesh V.; Qaim, Matin (2015): Production diversity and dietary diversity in smallholder farm households. In *Proceedings of the National Academy of Sciences of the United States of America* 112 (34), pp. 10657–10662. DOI: 10.1073/pnas.1510982112.

Sibhatu, Kibrom T.; Qaim, Matin (2018): Review: Meta-analysis of the association between production diversity, diets, and nutrition in smallholder farm households. In *Food Policy* 77, pp. 1–18. DOI: 10.1016/j.foodpol.2018.04.013.

Simmons, Phil; Winters, Paul; Patrick, Ian (2005): An analysis of contract farming in East Java, Bali, and Lombok, Indonesia. In *Agricultural Economics* 33 (s3), pp. 513–525. DOI: 10.1111/j.1574-0864.2005.00096.x.

Soullier, Guillaume; Moustier, Paule (2018): Impacts of contract farming in domestic grain chains on farmer income and food insecurity. Contrasted evidence from Senegal. In *Food Policy* 79, pp. 179–198. DOI: 10.1016/j.foodpol.2018.07.004.

Swinnen, J.F.M.; Kuijpers, R. (2020): Inclusive Value Chains to Accelerate Poverty Reduction in Africa. The World Bank. Washington DC (Jobs Working Paper, 37). Available online at http://documents.worldbank.org/curated/en/983221582592327153/Inclusive-Value-Chains-toAccelerate-Poverty-Reduction-in-Africa.

Swinnen, Johan F.M.; Vandeplas, Anneleen; Maertens, Miet (2010): Liberalization, Endogenous Institutions, and Growth: A Comparative Analysis of Agricultural Reforms in Africa, Asia, and Europe. In *The World Bank Economic Review* 24 (3), pp. 412–445. DOI: 10.1093/wber/lhq017.

Tabe-Ojong, Martin Paul; Hauser, Michael; Mausch, Kai (2022): Does Agricultural Commercialisation Increase Asset and Livestock Accumulation on Smallholder Farms in Ethiopia? In *The Journal of Development Studies* 58 (3), pp. 524–544. DOI: 10.1080/00220388.2021.1983170.

Tabe-Ojong, Martin Paul; Mausch, Kai; Woldeyohanes, Tesfaye B.; Heckelei, Thomas (2021): Three hurdles towards commercialisation: integrating subsistence chickpea producers in the market economy. In *European Review of Agricultural Economics*, Article jbab023. DOI: 10.1093/erae/jbab023.

Ton, Giel; Vellema, Wytse; Desiere, Sam; Weituschat, Sophia; D'Haese, Marijke (2018): Contract farming for improving smallholder incomes: What can we learn from effectiveness studies? In *World Development* 104, pp. 46–64. DOI: 10.1016/j.worlddev.2017.11.015.

Train, Kenneth E. (2009): Discrete Choice Methods with Similation. Second Edition. New York: Cambridge University Press.

Verpoorten, Marijke (2009): Household coping in war- and peacetime: Cattle sales in Rwanda, 1991–2001. In *Journal of development economics* 88 (1), pp. 67–86. DOI: 10.1016/j.jdeveco.2008.01.003.

Vos, Rob; McDermott, John; Swinnen, Johan (2022): COVID-19 and Global Poverty and Food Security. In *Annu. Rev. Resour. Econ.* 14 (1), pp. 151–168. DOI: 10.1146/annurev-resource-111920-013613.

Wang, H. Holly; Wang, Yanbing; Delgado, Michael S. (2014a): The Transition to Modern Agriculture: Contract Farming in Developing Economies. In *American Journal of Agricultural Economics* 96 (5), pp. 1257–1271. DOI: 10.1093/ajae/aau036.

Wang, Huaiyu; Moustier, Paule; Loc, Nguyen Thi Tan (2014b): Economic impact of direct marketing and contracts: The case of safe vegetable chains in northern Vietnam. In *Food Policy* 47, pp. 13–23. DOI: 10.1016/j.foodpol.2014.04.001.

Zeufack, Albert G.; Calderon, Cesar; Kambou, Gerard; Djiofack, Calvin Z.; Kubota, Megumi; Korman, Vijdan; Cantu Canales, Catalina (2020): frica's Pulse, No. 21, Spring 2020; Africa's Pulse; Africa's Pulse, No. 21, Spring 2020 : An Analysis of Issues Shaping Africa's Economic Future. World Bank. Washington, DC.

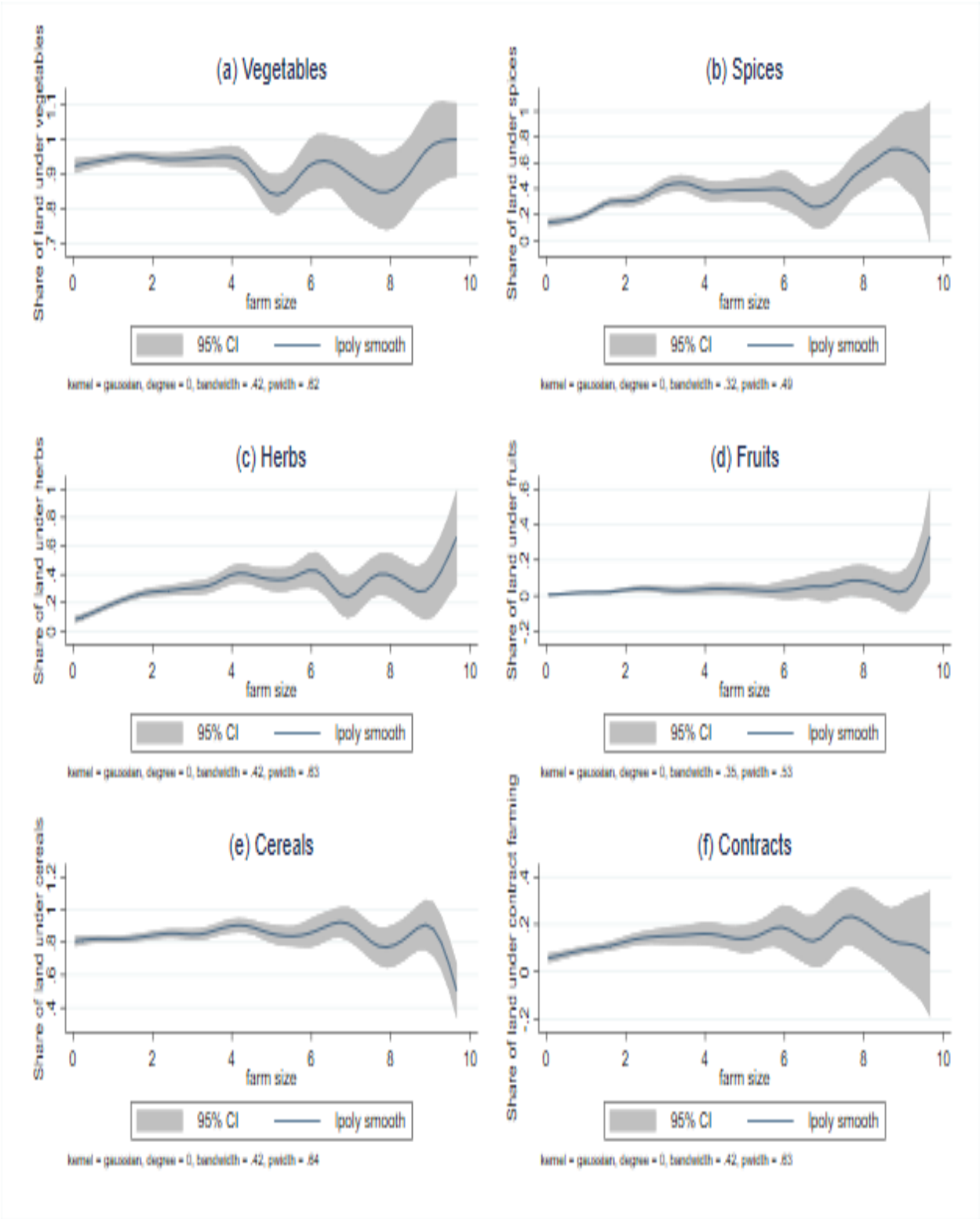
APPENDIX

Table A1: Correlates of value chain participation (Winter season)

	(1)	(2)	(3)	(4)
	Fruits and vegetables	Spices and herbs	Cereals	Contract farming
Age of head (years)	-0.042	-0.060***	0.003	-0.024
	(0.037)	(0.020)	(0.021)	(0.018)
Age (square)	0.001	0.001***	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Primary education (1/0)	-0.140	0.021	0.091	-0.228
	(0.174)	(0.132)	(0.131)	(0.186)
Incomplete secondary education (1/0)	0.366**	-0.073	0.040	-0.074
	(0.186)	(0.098)	(0.134)	(0.130)
Higher education (1/0)	0.018	-0.086	0.098	0.035
	(0.116)	(0.085)	(0.163)	(0.138)
Household size (number)	-0.006	0.034*	0.013	0.033
	(0.026)	(0.019)	(0.024)	(0.021)
Plot size(feddan)	-0.447***	0.255***	-0.283***	-0.003
	(0.081)	(0.081)	(0.073)	(0.058)
Plot (square)	0.030***	-0.010**	0.019***	-0.002
	(0.007)	(0.004)	(0.006)	(0.004)
Tropical livestock units	0.221***	-0.017	0.215***	0.019
	(0.061)	(0.028)	(0.042)	(0.031)
Wealth index	0.075	-0.015	-0.027	0.199***
	(0.086)	(0.065)	(0.041)	(0.051)
Productive assets	0.266***	0.131**	0.010	0.114*
	(0.061)	(0.054)	(0.056)	(0.059)
Fertilizer cost (EGP/feddan)	0.211**	-0.142	0.166*	-0.072
	(0.095)	(0.125)	(0.087)	(0.070)
Intercropping (1/0)	0.465***	-0.128	0.715***	0.266**
	(0.104)	(0.140)	(0.122)	(0.128)
Land ownership (1/0)	0.004	0.151*	0.264***	-0.314***
	(0.114)	(0.084)	(0.067)	(0.089)
Head is male (1/0)		0.152	-0.165	0.670
		(0.194)	(0.201)	(0.459)
Constant	1.175	1.433*	-0.618	-1.028
	(0.948)	(0.784)	(0.633)	(0.719)
Observations	2,237	2,237	2,237	2,237

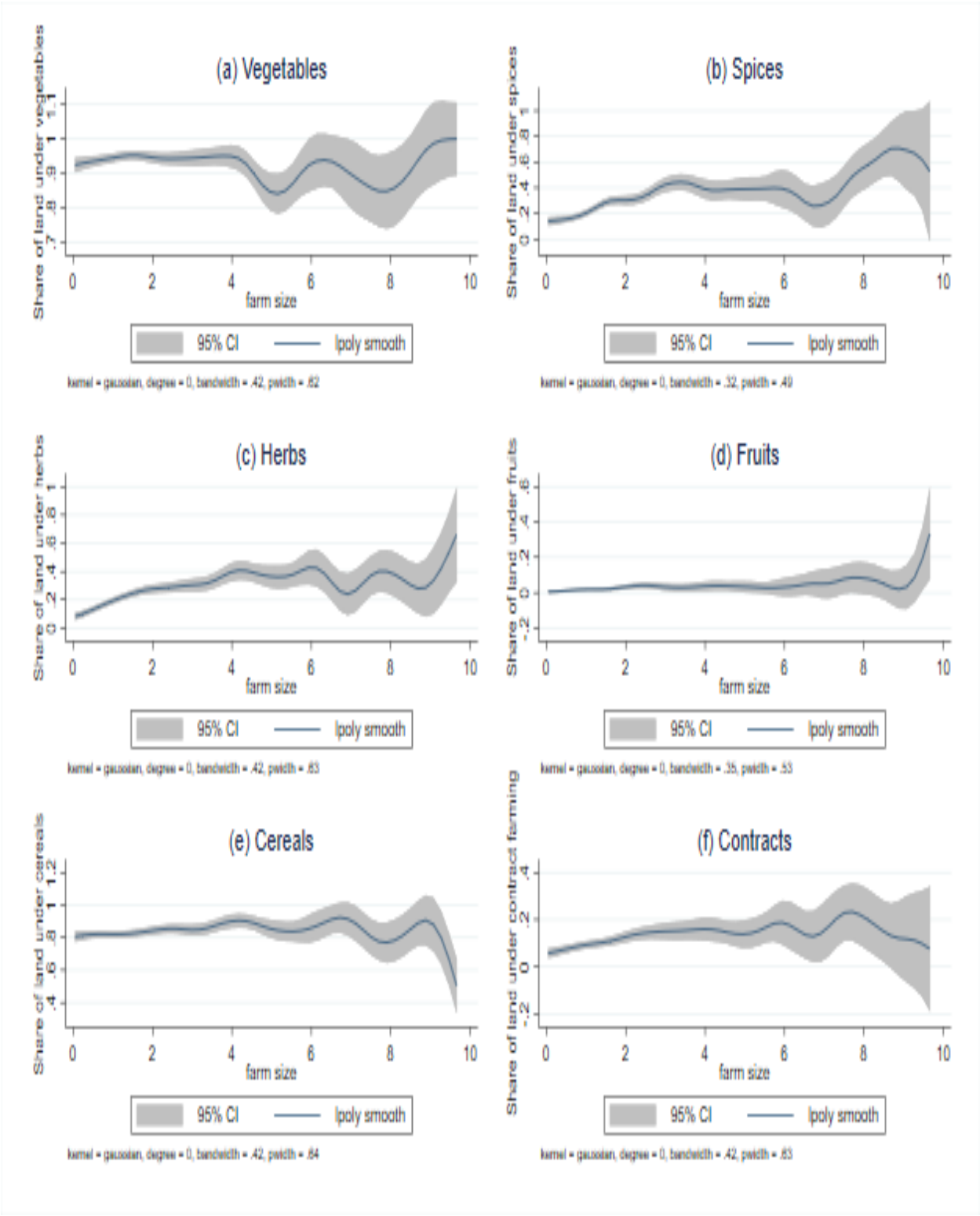
Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Figure A1: Non-parametric estimation of outcomes and farm size (plot level)



Source: Authors' visualization based on 2017/18 data from Upper Egypt.

Figure A2: Non-parametric estimation of outcomes and farm size (household level)



Source: Authors' visualization based on 2017/18 data from Upper Egypt.

The Egypt Strategy Support Program (EgSSP) is managed by the International Food Policy Research Institute (IFPRI) and is financially supported by USAID. This publication has been prepared as an output of Evaluating Impact and Building Capacity (EIBC) and has not been independently peer reviewed. Any opinions expressed here belong to the author(s) and are not necessarily representative of or endorsed by IFPRI.

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
A world free of hunger and malnutrition
IFPRI is a CGIAR Research Center

1201 Eye Street, NW, Washington, DC 20005 USA | T. +1-202-862-5600 | F. +1-202-862-5606 | Email: ifpri@cgiar.org | www.ifpri.org | www.ifpri.info